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Quantifying relationships between rock hardness, shore platform topography, and intertidal biota: Oregon Coast

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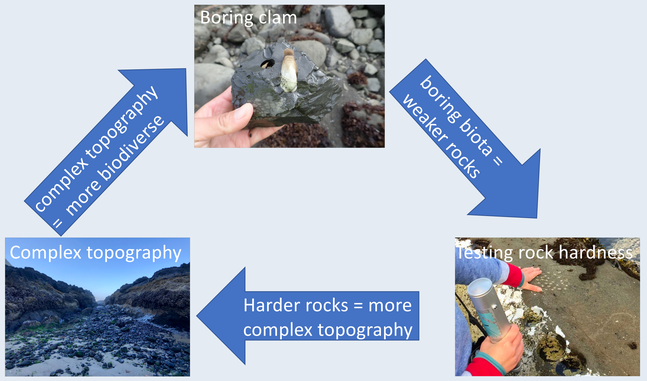
Predicted controls on rocky coast erosion

Background:

- Erosion of rocky coasts: a balance between substrate and the erosive action of biotic and abiotic processes.
- Less resisting strength = less force from waves and other processes needed to erode the rock.
- More resisting strength = rock able to maintain steep slopes = more habitat
- **Prediction**: Rock strength depends on rock type, abiotic weathering (salt, wind), biotic weathering (boring, plucking)
- **Prediction**: Harder rocks will have more complex (rougher) topography and higher biodiversity

Figure 1: Purple sea urchins reside in self-formed cavities.

Figure 2: Rocks in a bull kelp holdfast features as evidence of plucking.



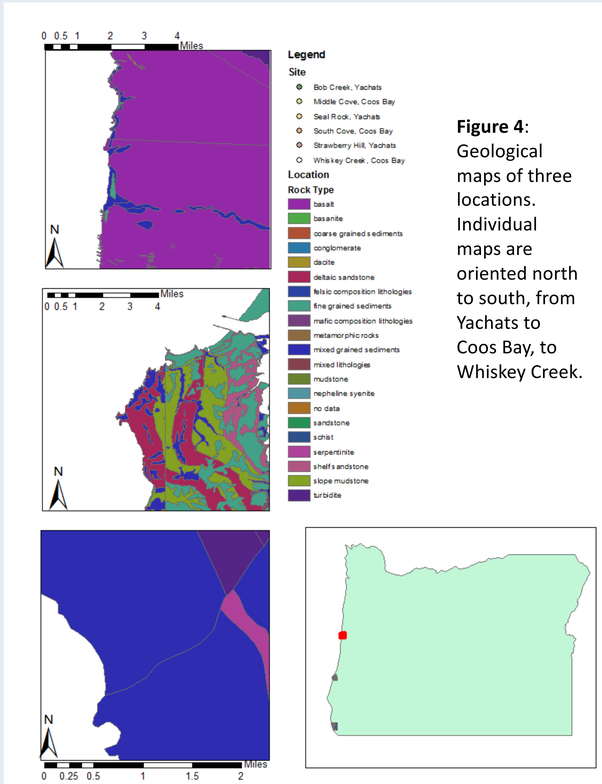


Figure 4: Geological maps of three locations. Individual maps are oriented north to south, from Yachats to Coos Bay, to Whiskey Creek.

Measuring topography and rock hardness

Topographic measurements:

- hand-held photographs of each site
- structure-from-motion photogrammetry in Agisoft PhotoScan to create dense clouds
- add geographical referencing to markers
- calculate surface roughness and related statistics in CloudCompare.

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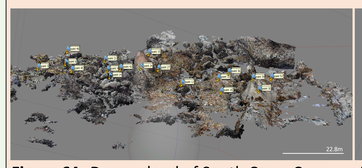

Figure 6A. Dense cloud of South Cove, Coos Bay. Created in Agisoft PhotoScan.

Figure 7A. Dense cloud of Bob Creek, Yachats. Created in Agisoft PhotoScan.

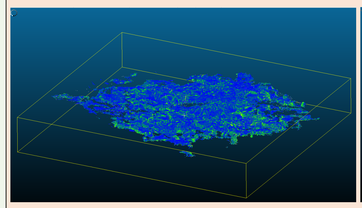

Figure 6B. Topographic roughness of South Cove created in Cloud Compare. Blue is low surface roughness; green is high.

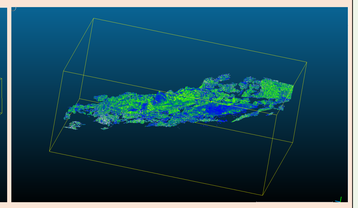

Figure 7B. Topographic roughness of Bob Creek created in CloudCompare. Blue is low surface roughness; green is high.

Rock hardness: To test the link between rock hardness and biodiversity, we collected rock hardness data along a transect using a Schmidt Hammer.:

- We took 30 hammer hits at approximately 5-11 points at each of the six sites.
- At each point, we recorded wetness, orientation, rock type, and rock position (in situ or not).
- After recording these observations, we recorded GPS locations for entry into PhotoScan and documentation.

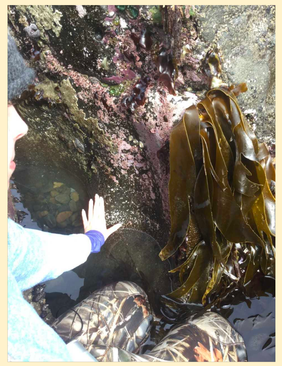

Figure 8. A point located at Strawberry Hill, Yachats.

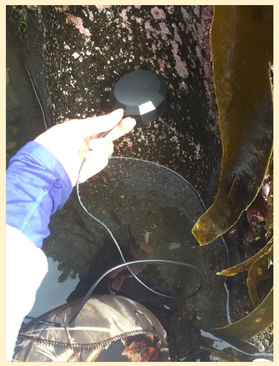

Figure 9. Taking the GPS point

We analyzed the rock hardness data using **Univariate Regression Trees (URT)**:

- Uses a single quantitative response variable (rock hardness) and tests multiple explanatory variables.
- Unlike multiple regression, the method does not assume the shape of the relationship.
- URTs are hierarchical, meaning they assign a relative explanatory power to the possible explanatory variables.

Preliminary Results

Preliminary results:

- Sites with softer rocks tend to have smoother shore platforms
- Spatial organization of the tide pools could protect rocks from the erosive effect of waves
- Document the effects of substrate strength at a spatial scale relevant to intertidal biodiversity

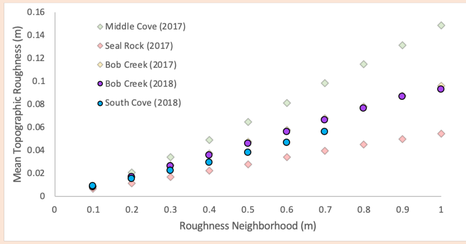

Figure 10: Comparing the mean topographical roughness with the kernel roughness neighborhood. Higher values of surface roughness indicate higher complexity. South Cove (2018) points still being processed.

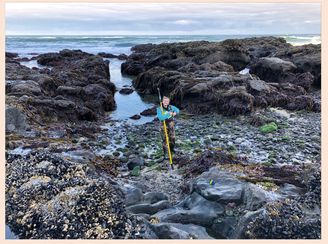

Figure 11: Bob Creek, Yachats

Figure 12: South Cove, Coos Bay

Next steps:

- conduct texture calculations on the surface roughness
- compute smoothness statistics (homogeneity)
- compute uniformity statistics (entropy)

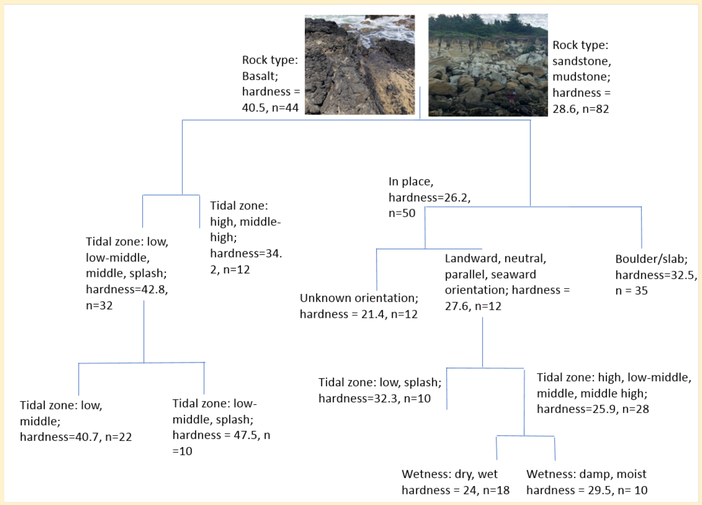

Figure 13. Statistics-based model of abiotic factors of rock hardness. Primary factor is rock type, with basalt lithologies on the left and sandstone/mudstone on the right. Secondary factors driving rock hardness vary in importance between rock types.

Next steps:

An incorporation of biotic data using URT:

- Sort organisms into functional groups based on erosive process type.
- Capture relationship between rock hardness and encrusting life including algae ("seaweed"), mussels, urchins and others.

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